

A SUGGESTED SUCCESS MODEL FOR THE INITIAL IMPLEMENTATION  
OF SCIS IN AN URBAN SETTING

Patricia P. Price  
Baldwinsville School District  
Baldwinsville NY 13027

and

Larry E. Schafer  
Syracuse University  
Syracuse, NY 13210

Objectives and Rationale

In these days of defeated school budgets and demands for greater fiscal accountability, school districts are forced to investigate every possible means of conserving tax dollars. A school system can no longer afford to experiment with costly, district-wide trial programs. This is particularly true in the case of material centered science curricula such as the Science Curriculum Improvement Study (SCIS). The alternative to a massive and risky trial implementation could lie in a more limited and carefully thought out approach.

The purpose of this study was twofold:

1. to identify which combination of preselected teacher and school variables had the most positive effect on student outcomes in SCIS within a large urban setting, and
2. to use these identified variables, i.e., success profile, as a model for the selection of a few schools in which the initial trial implementation of SCIS could occur.

Methodology and Design

The variables observed on 4100 fifth and sixth grade SCIS students were: attitude toward SCIS, student achievement in SCIS life science and SCIS physical science. The variables observed on the 160 teachers involved in the study were: the grade taught, if the teacher was trained in SCIS methods and materials, the age of the teacher, years of teaching experience, the number of college hours in science content and science methods, minutes per week spent on SCIS in the classroom, the number of life and physical science chapters taught, the teacher's attitude toward SCIS, the teacher's scores on the life and physical science tests. Other variables observed were: the SCIS consultant's perception of the school's interpersonal climate, the principal's attitude toward science; the school's size; the school's racial ratio and the school's socioeconomic status as measured by Title I funding. Stepwise multiple regression analysis was used to initially clarify the statistical significance of the independent variables in reference to the dependent variables. The significant independent variables for

each dependent variable were then combined with the categorical treatment variables training and Title I to create trait X treatment interaction terms. Stepwise multiple regression analysis was then used to determine which of the single variables and their interaction terms were significant when considered together against each dependent variable.

#### Instruments and Data

The teacher data was gathered by means of a teacher questionnaire, an attitude toward SCIS instrument, SCIS life and physical science instruments. The student data was gathered via a student attitude toward SCIS instrument and SCIS life and physical science instruments. Other data were obtained from school records.

#### Results and Conclusions

The following variables were identified with positive student outcomes in SCIS:

1. Teacher age (average) = 35 years
2. Teacher's years experience (average) = 9 years
3. School interpersonal climate = positive, cooperative at all levels
4. Principal attitude toward elementary science = positive
5. School socioeconomic status = middle-upper socioeconomic status
6. Teachers should be competent in SCIS concepts and processes
7. Teachers should have SCIS training
8. Physical science should be taught before the life science unit.

In conclusion, it is recommended that the above variables be included in a success profile model to be used in the selection of schools for an initial implementation of SCIS in a large urban school district.

CONCURRENT SESSION G

Session G-4

Instruction

Presiding:

Heidi Kass  
Dept. of Secondary Education  
University of Alberta  
Edmonton, Alberta  
Canada T66 2G5

The Effect of Demonstration-Theory Versus Theory-  
Demonstration Sequences and of Expected and Dis-  
crepant Outcomes of A Demonstration Experiment on  
Subject's Test Scores of Bloom's Knowledge,  
Comprehension and Application Levels

Al Evans  
Georgia State University  
203 Log Cabin Drive  
Smyrna GA 30080

The Effect of Four Types of Study-Guide Questions  
and Structure on Learning From Written Text

Don Kauchak  
University of Utah  
Salt Lake City UT 84112

and

Paul Eggen and Sandra Kirk  
University of North Florida  
Dept. of Elementary and Secondary Education  
P.O. Box 17074  
Jacksonville FL 32216

Disruptive and Helpful Testing Cues in Science:  
An Index by Intensity and Frequency

William J. Kermis  
Syracuse University and Liverpool School District  
Dept. of Science Teaching  
101 Heroy Geology Laboratory  
Syracuse NY 13210

Evaluator:

N. Eldred Bingham  
Editor, "Science Education"  
1718 NW 10th Avenue  
Gainesville FL 32605

THE EFFECT OF DEMONSTRATION—THEORY VERSUS THEORY—DEMONSTRATION  
SEQUENCES AND OF EXPECTED AND DISCREPANT OUTCOMES OF A  
DEMONSTRATION EXPERIMENT ON SUBJECT'S TEST SCORES AT  
BLOOM'S KNOWLEDGE, COMPREHENSION AND APPLICATION LEVELS

Al Evans  
Georgia State University  
Smyrna GA 30080

Statement of Problem

Demonstration experiments are an important teaching tool in science. There is a considerable body of anecdotal information on how to demonstrate, when to demonstrate, what to demonstrate, and to whom to demonstrate. Much of this information is contradictory. There are two themes on which many authorities comment. First is that demonstrations are more effective if the outcome is counter-intuitive or discrepant. The second theme is that one order or sequencing of theory and demonstration is superior. The recommended sequence varies from author to author. Authors support their suggestions with rationales, but no experimental study using order and discrepancy as variables has been reported. Demonstrations are performed daily in thousands of science classes. Experimental evaluation of the importance of order of presentation and discrepancy of outcome would be useful to teachers making decisions about what type of demonstration to present and how to sequence the material.

Design

A 2 x 2 multivariate design with three dependent variables and two covariates and random assignment of subjects was used.

Independent Variables

1. Order of Presentation (Two levels: Demonstration-Theory, Theory-Demonstration)
2. Discrepancy of Experiment (Two levels: Expected outcome, surprising outcome).

Dependent Variables

The three dependent variables were test scores which were obtained from the subjects' responses to multiple choice questions which were written at Bloom's knowledge, comprehension, and application levels.

### Covariates

1. Otis-Hennon IQ
2. Eighth grade science grade.

### Classificatory Variable

Sex. The major research hypotheses were that there would be no significant ( $\alpha \leq .05$ ) differences between the groups on the three levels tested. Minor hypotheses were that no significant interactions of the independent variables, IQ, or sex would be found. A power of .90 was estimated.

The purpose of the study was to provide useful information to teachers using demonstrations, not to test any particular theory. However, Ausubel's advance organizer theory would predict that the theory-demonstration order would produce higher test scores. Festinger's theory of cognitive dissonance would predict that the discrepant experiment would produce higher test scores.

### Procedure

A script was prepared for an experiment demonstrating the solubility of gases as a function of temperature. The script was written in two separate sections. The theory section was written on an abstract level and presented concepts which explained the demonstration. The demonstration section was written on the concrete level and referred to observable phenomena. Two different sets of chemicals were used to produce two demonstration tapes with identical scripts but different discrepancy levels.

The scripts were performed by an actor, and were recorded on color videotape. The tape was duplicated and edited to produce four five-minute treatments.

A pilot study was used to evaluate and refine multiple choice questions on the knowledge, comprehension and application levels which were designed to measure the learning outcomes of the videotape.

The final instrument consisted of 35 multiple choice items. It was given to 113 average and above average eighth grade students immediately after the videotape presentation. Twenty-eight subjects had been randomly assigned to each of the four treatment groups.

### Results

A MANOVA analysis revealed no significant differences in multiple choice measures of knowledge, comprehension, or application scores as a function of different orders of presentation or of different levels of discrepancy for a videotaped demonstration of an experiment in science.

# THE EFFECT OF FOUR TYPES OF STUDY-GUIDE QUESTIONS AND STRUCTURE ON LEARNING FROM WRITTEN TEXT

Don Kauchak  
University of Utah  
Salt Lake City UT 84112

and

Paul Eggen  
Sandra Kirk  
University of North Florida  
Jacksonville FL 32216

## Objective

The purpose of the study was to investigate the effects of study questions in different forms (verbatim, true/false, paraphrased, and open ended) on the learning of science content from written text. A second purpose was to measure the effect of specifying answer location on question effectiveness.

## Rationale

Study guides in the form of questions are often used to aid students' progress through science text materials but variables determining their effectiveness are largely unmeasured. Studies have shown that higher level questions produced better scores on an evaluation level posttest without a decrement in knowledge level performance. In particular, one showed that subjects producing their own examples of a principle scored higher than a control and recall condition (Watts and Anderson, 1971). Verbal learning research supports these findings with "deeper levels of processing" characterized by semantic rather than orthographic processing resulting in greater retention scores (Craig and Lockhart, 1972).

An additional practice common to science classrooms is specifying the page where answers to study questions can be found. The present study investigates both these lines of research.

## Method and Design

Eighty-five fourth grade students were randomly assigned to four treatment groups. Each was given a passage from the students' weekly science newsletter. The four experimental groups were given study guides with eight verbatim, true/false, paraphrased, and open ended questions, respectively. Half the students' study guides referred to the paragraph number where the answer for each question could be found (the structured condition). The result was a 4 x 2 factorial design.

### Instruments

A posttest consisting of two parts was prepared. The first subtest had eight questions identical to the verbatim questions in the study guide and the second subtest had 12 incidental questions, which covered the content of the newsletter but were unrelated to the study guide questions. The Kuder-Richardson 21 reliability for the posttest was .79.

### Results

Two-way analysis of variance was used to determine whether differences existed among groups, on total scores and on the verbatim and incidental subtests.

For total scores and for both subtests two-way interactions were found to be significant. For students not receiving answer location (the unstructured condition), total scores for true/false Ss were significantly higher than both verbatim and open ended; on the verbatim subtest true/false Ss scored significantly higher than verbatim; and on the incidental subtest true/false Ss scored significantly higher than all three other groups. There were no significant differences between groups of Ss receiving question locations.

For verbatim, open ended and paraphrased groups, Ss not given locations scored higher than those given locations.

### Discussion

The study results raise questions about the advisability of identifying answer locations in study guides. Comparison by treatment showed the verbatim unstructured group scored higher than the verbatim structured group on all measures. Further, when comparisons by structure were made no significant differences were found for the structured group while there were differences among the unstructured group. Possible reasons may be as follows: Lack of structure required a more thorough scanning of the information in the newsletter resulting in more careful study of the information. Further, the true/false questions required more thorough processing than did the other question forms because the learner had to ascertain the veracity of the statement which resulted in higher posttest scores.

The locating of the answers for the structured group essentially neutralized the treatment effects. More careful analysis of forms of questions are required to compare their effectiveness, particularly for different age groups, before generalizations can be made.



## References

Craig, F. and R. Lockhart. "Levels of Processing: A Framework for Memory Research." Journal of Verbal Learning and Verbal Behavior, 11:671-684, 1972.

Watts, G. and R. Anderson. "Effects of Three Types of Inserted Questions on Learning from Prose." Journal of Educational Psychology, 62:387-394, 1971.



DISRUPTIVE AND HELPFUL TESTING CUES IN SCIENCE: AN  
INDEX BY INTENSITY AND FREQUENCY

William J. Kermis  
Syracuse University  
Syracuse NY 13210

Students in science courses; as well as most other courses, are test conscious and become anxious over testing (Sarason, Davidson, Light-hall, Waite and Ruebush, 1960). Spielberger, Anton and Bedell (1975) concluded that high levels of test anxiety often have a negative effect on tests that require formal operations. McKinnon and Renner (1971) and Kolodiy (1975) reported that science tests at the college level require formal operations. Wine (1971) suggests that high test anxious (HTA) and low test anxious (LTA) students direct their attention to different testing cues. HTA students attend to disruptive cues which debilitate test completion, whereas LTA students attend to helpful cues which facilitate test completion. Spielberger (1972) and Anton (1976) state that there is a vital need to isolate actual testing cues, disruptive and helpful, by intensity and frequency that students who differ in levels of test anxiety direct attention to.

The primary purpose of this study was to develop an objective measure that will accurately assess the types of testing cues by intensity and frequency for HTA and LTA students.

The sample consisted of 400 students in two physical geology classes. Data was collected during two sessions. The first session was designed to obtain a measure of test anxiety for each student. The second session was designed to index testing cues by intensity and frequency. A 42 percent return was obtained.

The State-Trait Anxiety Inventory (STAI) developed by Spielberger, Gorsuch and Lusken (1970) is a self-report instrument that measures an individual's personality trait of test anxiety. A median-split was performed (Hays, 1973, p. 218) to obtain levels of test anxiety (HTA and LTA). Disruptive and helpful testing cues were obtained from an earlier study. At that time, HTA and LTA students were queried as to the things they felt were extremely disruptive and helpful to their test performance. A list of 55 testing cues, disruptive and helpful was obtained. The 55 testing cues were then used to construct the Test Cue Identification Questionnaire (TCIQ). The questionnaire was designed to explore the way HTA and LTA students react, intensity and frequency, to test related cues, disruptive and helpful. A sample cue and response is provided: "If a teacher asks only memory questions it is an extremely disruptive test cue 100 percent of the time.

Data was analyzed using a SPSS program for the basic statistics of cumulative frequency and mean. The results produced eleven significant cues, seven disruptive and four helpful, that were identified by HTA and LTA students. HTA students contributed more to the

disruptive cues, whereas LTA students contributed more to the helpful cues which is supportive of earlier findings by Wine (1971).

Two major implications for science teaching are apparent in this study. First the elimination of disruptive cues and implementation of helpful cues will provide a testing environment conducive to maximum performance for both HTA and LTA students. Second, research is needed to establish what portion of the variance in science grades of introductory students is attributed to test anxiety level X type of testing cue.

#### References

- Anton, W. D. "An Evaluation of Outcome Variables in the Systematic Desensitization of Test Anxiety." Behavior Research and Therapy, 14(3):217-224, 1976.
- Hays, W. L. Statistics for the Social Sciences (2nd edition). New York: Holt, Rinehart and Winston, 1973.
- Kolodiy, G. D. "The Cognitive Development of High School and College Science Students." Journal of College Science Teaching, 20-22, 1975.
- McKinnon, J. W. and J. W. Renner. "Are Colleges Concerned with Intellectual Development?" American Journal of Physics, 39: 1047-1052, 1971.
- Sarason, S. B., K. S. Davidson; J. J. Lighthall; R. R. Waite; and B. K. Ruebush. Anxiety in Elementary School Children. New York: John Wiley & Sons, 1960.
- Spielberger, C. D.; R. L. Gorsuch; and R. E. Luskene. STAI Manual for the State-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologists Press Inc., 1970.
- Spielberger, C. D. "Anxiety as An Emotional State." In C. D. Spielberger (ed.), Anxiety: Current Trends in Theory and Research, Vol. 1. New York: Academic Press, 23-49, 1972.
- Spielberger, C. D.; W. D. Anton; and J. Bedell. "The Nature and Treatment of Test Anxiety?" In M. Zuckerman and C. D. Spielberger (eds.) Emotions and Anxiety: New Concepts, Methods and Applications. New York: LEA-Wiley, 1975.
- Wine, J. "Test Anxiety and Direction of Attention." Psychological Bulletin, 76:92-104, 1971.

CONCURRENT SESSION G

Session G-5

Learning

Presiding:

Donald Starkweather  
Science Education Department  
State University College  
Oneonta NY 13820

Logical Ability, Formal Thought and Achievement  
in Physics

Fred Seeber, George Pallrand, Geraldine  
VanDenberg and David VanHarlingen  
Rutgers University  
New Brunswick NJ 08903

The Mole Concept: Investigation of an Hierchical  
Model

A. K. Griffiths  
Dept. of Curriculum and Instruction  
Memorial University of Newfoundland  
St. John's, Newfoundland  
Canada A1C 5S7

and

Heidi Kass  
University of Alberta  
Edmonton, Alberta  
Canada T6G 2E1

The Effect of Student Manipulation of Molecular  
Models on Chemistry Achievement According to  
Piagetian Level

Dorothy Gabel  
School of Education  
Indiana University  
Bloomington IN 47401

Evaluator:

Ashley Morgan  
Georgia State University  
University Plaza  
Atlanta GA 30303

# LOGICAL ABILITY, FORMAL THOUGHT AND ACHIEVEMENT IN PHYSICS

Fred Seeber  
George Pallrand  
Geraldine VanDenberg  
David VanHarlingen  
Rutgers University  
New Brunswick NJ 08903

Formal operational thought in Piagetian theory has stimulated considerable interest among science educators. The theory describes formal thought in terms of increasingly integrated cognitive structures and as a sequence of stages culminating at the formal operational level. Operationally, ability to operate at this level is established by performance on tasks within schema such as combinatorial, proportional, probabilistic and correlational reasoning. These are also abilities closely associated with scientific thought. According to the theory, one's ability to function at the formal level is dependent upon the presence of a system of combinatorial logic. The ability to use propositional logic, on the other hand, has traditionally been associated with formal thought and success in science.

This study examined how the ability to use propositional logic was related to achievement in a university level physics course. The intent was to investigate the extent to which the ability to use propositional logic is a predictor of physics achievement.

The subjects were 450 students taking an introductory level physics course for science and pre-health professions majors at a large Eastern university. A test of logical operators was administered, along with a test for mathematical ability, and a battery of spatial-visual tasks. A factor analysis isolated strong logic and mathematics factors which accounted for over 50 percent of the variance.

In addition, chi-square analysis suggests a hierarchy in the ability to use certain operators and that some subset of these are the major predictors of course success. This result will be compared to the results of another study which has been conducted relating these operators to Piagetian schema.

The strong relationship of logical operators to achievement in introductory level physics courses suggests a task analysis of semester and unit examinations. This could provide significant information relating these operators to particular aspects of achievement. These results suggest, more importantly, that facility with such operators may exist as a precondition to achievement in such a course.

# THE MOLE CONCEPT: INVESTIGATION OF AN HIERARCHICAL MODEL

A. K. Griffiths  
Memorial University  
St. John's, Newfoundland

and

J. Kaas  
University of Alberta  
Edmonton, Alberta, Canada

The main purpose of the study was to identify a learning hierarchy for the mole concept as it appears in introductory high school chemistry. A secondary purpose was to evaluate the relative importance of developmental level, in the neo-Piagetian sense, and availability of subordinate skills in the acquisition of related superordinate skills in the hierarchy.

An eight-element learning hierarchy was generated by task analysis and empirically validated by application of three methods currently proposed for this purpose. The sample consisted of 269 grade ten students in a course based on CHEM study materials. In order to determine the degree of transfer from subordinate to superordinate skills, the sample was assigned by intact classes to one of two sub-groups. Each student in the sub-group designated as remedial was required to complete two take-home remedial units prior to instruction in the next skill. With this exception, teachers were encouraged not to depart from their usual instructional practices.

Several days prior to the start of instruction relating to the content of the hierarchy, a set of neo-Piagetian tasks and a test of second-order operations were administered. Three quizzes on skills from the hypothesized hierarchy were administered at appropriate times during instruction, followed by a final chemistry test consisting of four items on each skill. To estimate reliability of the chemistry skills tests, phi coefficients between items testing the same skill were computed. Nearly all were significant ( $p \leq 0.001$ ). Cohen's  $\kappa$  was used to determine the consistency of mastery decisions for each subject on each skill. All but one estimate of  $\kappa$  were significant ( $p \leq 0.001$ ).

The White and Clark, order-theoretic, and Dayton-Macreedy hierarchy validation methods, when applied to the final chemistry test data, yielded an hierarchy considered to be psychometrically valid which contained seven of the eight skills of the hypothesized hierarchy. The test of transfer revealed a significant relationship between gain in subordinate skills and related superordinate skills.

In addition to their use as determinants of the mastery status of individuals, the chemistry tests provided achievement scores for use in regression analyses. Parallel forms reliabilities for each skill on the quizzes and final test ranged from 0.36 to 0.74 and, with the exception of one skill, internal consistencies ranged from 0.72 to 0.92. Significant but moderate correlations (the largest being 0.43)

were found between scores on each of the developmental tests and tests for each of the chemistry skills. Collectively and with one exception, the two developmental level tests accounted for 13 to 18 percent of variance for the tests of chemistry skills. When the contributions from the two developmental tests are entered into stepwise regression equations after the contributions from immediate superordinate skills (with  $R^2$ 's ranging from 0.15 to 0.51), the increment in  $R^2$  ranges from 0.005 to 0.056. The results support the suggestion that the availability of immediate skills is more important than learner development level in predicting achievement on actual skills examined.



# THE EFFECT OF STUDENT MANIPULATION OF MOLECULAR MODELS ON CHEMISTRY ACHIEVEMENT ACCORDING TO PIAGETIAN LEVEL

Dorothy Gabel  
Indiana University  
Bloomington IN 47401

In the past few years science educators have determined that many students enrolled in high school and college science courses do not think on the formal operational level (Chiappetta, 1970). Because a substantial number of concepts presented in science courses requires formal thinking several investigators have sought methods that will make formal concepts more accessible to concrete thinkers. One method that has been tested in chemistry courses is the manipulation of concrete molecular models. Results of studies in this area have been mixed. Talley (1973) showed that college student chemistry achievement on high level questions was higher with the manipulation of models. Sheehan (1970) found that both concrete and formal students profited from the manipulation whereas studies by Drugge and Kass (1978) and Goodstein and Howe (1978) fail to confirm this. The purpose of this study was to examine the effect of the manipulation of molecular models by high school students over a long period of time (entire school year) on chemistry achievement according to the student's Piagetian level. The research was sponsored by the Proffitt Foundation.

The sample consisted of 238 students enrolled in four schools (one rural, one suburban, two metropolitan) in central and south central Indiana. Seven teachers and their students participated in the study. Teacher's classes were randomly assigned to one of the two treatments.

The treatment consisted of students actively manipulating molecular models versus observing the teacher manipulate the models. Study guides for eight lessons were distributed to teachers to provide a minimum treatment base and teachers were encouraged to use the same mode of instruction with their classes throughout the year.

Students were classified as concrete, lower formal, and upper formal via scores on a modified form of the Longeot test. This test was administered at the beginning and end of the school year in order to also determine whether the treatment was effective in modifying students' Piagetian levels.

The dependent variables in this study consisted of the American Chemical Society (ACS) Achievement Test in High School Chemistry (reliability = 0.74), selected items from this same test that directly related to the study guides (reliability = 0.41), and a 39-item composite of test items embedded in eight unit tests relating to the eight units (reliability = 0.60).

Data were analyzed using 3 x 2's analyses of variances with three levels of Piagetian developmental stage and two levels of treatment. The following results were obtained.



1. Students who were classified as formal achieved significantly higher than those classified as concrete on the ACS test at the 0.001 level and on the content test at the 0.015 level.
2. Students in the active manipulation group performed significantly higher than those who observed manipulations on the ACS test at the 0.003 level, on the ACS subtest at the 0.05 level, and on the content test at the 0.055 level.
3. There were no significant interaction effects for the ACS test or ACS subtest but there was a significant interaction at the 0.029 level for the content test. Formal operational students benefitted more from active manipulation than did concrete students.

Results of this study confirm Sheehan's findings that manipulation of models is beneficial for both concrete and formal students. When used over a long time period the manipulation appears to improve chemistry achievement.

#### References

- Chiappetta, E. L. "A Review of Piagetian Studies Relevant to Science Instruction at the Secondary and College Level." Science Education, 60(2):253-261, 1976.
- Drugge, N. L. and H. Kass. "Effect of Selected Analogies: Understanding of Scientific Explanations." ERIC Reproduction Service, ED 152537, 1978.
- Goodstein, M. and A. C. Howe. "The Use of Concrete Models in Secondary Chemistry Instruction." Journal of Research in Science Teaching, 15:361-366, 1978.
- Sheehan, D. J. "The Effectiveness of Concrete and Formal Instructional Procedures with Concrete Operational and Formal Operational Students." Unpublished doctoral dissertation. Dissertation Abstracts International, 31(6-A):2748, 1970.
- Talley, L. H. "The Use of Three Dimensional Visualization as a Moderator in the Higher Cognitive Learning Concepts in College Level Chemistry." Journal of Research in Science Teaching, 10:263-269, 1973.

RESEARCHERS POTPOURRI

Presiding:

Arthur L. White  
Ohio State University  
Columbus OH 43210

Joan Dnea  
Price Lab School  
Cedar Falls IA 50613

and

Linda R. DeTure  
University of Florida  
Gainesville FL 32605

and

Russell W. Yarny  
University of Georgia  
Athens GA 30602

Topic:

NSTA-NARST Cooperative Research Efforts

The influence of science education research on classroom teaching practice is not as great as many would like it to be. This lack of influence may be due to a number of reasons. Many feel that research findings and their implications are inadequately communicated to the classroom teachers. However, this lack of influence may also be due to the perceived lack of relevance for teachers as they look for guidance to deal with daily concerns and decisions which they face in the classroom.

A mechanism for two-way communication and cooperation between teachers and researchers is needed. This mechanism should be designed to facilitate the identification by teachers of research problems relevant to teachers needs, to insure the quality of the research in order to give valid-generalizable results, and to help in the translation of the research findings into language that connects it to classroom practice.

NARST and NSTA, through the respective research committees, are involved in a cooperative effort devoted to identifying research priorities and developing a mechanism for proposing, designing, conducting and reporting research relating to classroom practice. This would serve to establish better credibility of researchers with teachers and of teachers with researchers thus making the impact of research on classroom practice more likely. This would also increase the probability that the classroom practices would produce the desired science learning.

NARST AWARD PAPER

Presiding: John T. Wilson  
University of Iowa  
Iowa City IA 52242

The outstanding paper given at the 1978 annual meeting will be presented again and discussed.

CONCURRENT SESSION H

Session H-

Topic: The Status of Pre-College Science, Mathematics, and Social Science Education, 1955-1975

Presiding: William G. Lamb  
Frederica Academy  
Hamilton Road-Box 1217  
St. Simons Island GA 31522

The Status of Pre-College Science, Mathematics and Social Science Education, 1955-1975: Enrollment and Financing

Robert W. Howe  
Ohio State University  
254 Arps Hall, 1945 North High Street  
Columbus OH 43210

The Status of Pre-College Science, Mathematics and Social Science Education, 1955-1975: Practices and Needs Assessments

Stanley L. Helgeson  
Ohio State University  
254 Arps Hall, 1945 North High Street  
Columbus OH 43210

The Status of Pre-College Science, Mathematics and Social Science Education, 1955-1975: Science Teacher Education

Patricia E. Blosser  
Ohio State University  
254 Arps Hall, 1945 North High Street  
Columbus OH 43210

Evaluator: Chris A. Pouler  
Prince George's County Public Schools  
Eleanor Roosevelt Senior High School  
7601 Hanover Parkway  
Greenbelt MD 20770

THE STATUS OF PRE-COLLEGE SCIENCE, MATHEMATICS AND SOCIAL SCIENCE  
EDUCATION, 1955-1975: ENROLLMENT AND FINANCING

Robert W. Howe  
Ohio State University  
Columbus OH 43210

The two decades, 1955-1975, marked the first major investment of federal monies directly in curricular and instructional concerns. The Elementary and Secondary Education Act (ESEA) of 1965 continued the pattern of direct investment, initiating programs to deal with special groups within the educational community. Concern for the educational needs of students and for program effectiveness evaluation was specifically mandated within this Act.

Data analyzed indicate enrollments in public schools increased until 1969 and then began to decline. When data for only grades K-6 are analyzed, peak enrollment appeared to occur in 1968. Current projections for enrollment will be discussed and their implications for science education highlighted.

When financing and school control are considered, a pattern of increasing state control becomes evident. States vary extensively in the amount of control exerted over the science curriculum. In addition, method of control varies in legislative and regulatory forms. Examples of state influence or control will be discussed as these related to school size and consolidation, school curriculum, teacher certification, textbook and instructional materials selection, and minimum competencies and accountability.

THE STATUS OF PRE-COLLEGE SCIENCE, MATHEMATICS, AND SOCIAL SCIENCE  
EDUCATION, 1955-1975: PRACTICES AND NEEDS ASSESSMENTS

Stanley L. Helgeson  
Ohio State University  
Columbus OH 43210

This study was one of three funded by the National Science Foundation in the summer of 1976 to assess practices in pre-college education and to provide baseline information on needs so future programs in science, mathematics, and social science education can be targeted to meet documented national concerns.

The specific purpose of the study was to:

1. review, analyze, and summarize appropriate literature related to pre-college science instruction, to science teacher education, and to needs assessment efforts; and
2. identify trends and patterns in the preparation of science teachers, science teaching practices, curriculum materials, and needs assessments in science education

during the period 1955-1975.

Because this was an archival study, the procedures focused on identifying, retrieving, and analyzing existing literature rather than on generating new information. Major sources of information included the ERIC data base, Education Index, Reader's Guide to Periodical Literature, Dissertation Abstracts International, published books and journals, federal agencies' files and collections, state department of education archives, and reports from conferences and committees. Selection of documents for review was based upon:

1. generalizability of results based upon size of population, sampling techniques, and methods of analysis;
2. summarization of data or research reports (e.g., reviews of research);
3. importance or significance as indicated by publication in a refereed journal or as a committee report; and
4. representativeness of a type or kind of document (e.g., curriculum guide).

The reports will be organized around four major considerations:

1. Existing Practices and Procedures in Schools
2. Science Teacher Education
3. Controlling and Financing Education
4. Needs Assessment Efforts

This paper in the paper set will focus on practices and needs assessment efforts in science education. Findings summarizing the literature in each category will be presented.



THE STATUS OF PRE-COLLEGE SCIENCE, MATHEMATICS AND SOCIAL SCIENCE  
EDUCATION, 1955-1975: SCIENCE TEACHER EDUCATION

Patricia E. Blosser  
Ohio State University  
Columbus OH 43210

The two decades, 1955-1975, are unparalleled in the degree of activity in science education. Millions of dollars were devoted to the cooperative involvement of scientists, educators, and learning theorists in the development of science curriculum materials. Extensive programs were developed and conducted to upgrade and update the science content background of teachers and to train them in the use of the new curricula.

The focus of this project was a status report on the impact of such activity in curriculum development, teacher education, instruction, and needs assessment. Specifically, the purpose of this project was to:

1. review, analyze, and summarize appropriate literature related to pre-college science instruction, to science teacher education, and to needs assessment efforts; and
2. identify trends and patterns in the preparation of science teachers, teaching practices, curriculum materials, and needs assessments in science education

during the period 1955-1975.

This paper in the set will focus on literature related to science teacher education: pre-service and in-service. Included in the survey are documents on guidelines for teacher education programs in science, certification requirements, program descriptions, research studies, and position papers. Findings summarizing the literature in each category will be presented.

CONCURRENT SESSION H

Session H-2

Paper Set: Factors Affecting Achievement in Science

Presiding:

Frances Lawrenz  
3311 E. 52nd Street  
Minneapolis MN 55417

Analogy and Physics Achievement

Morris A. Enyeart  
Rutgers University  
New Brunswick NJ 08903

Spatial Reasoning and Formal Thought as Factors  
in Science Achievement for New Zealand Students

Michael D. Piburn  
Rutgers University  
New Brunswick NJ 08903

The Effect of A Community College Education on  
the Cognitive Development of Students in Liberal  
Arts and Laboratory Technology Curricula: An  
Intervention Study

Alan Sherman  
Dept. of Science and Humanities Education  
Graduate School of Education  
Rutgers University  
New Brunswick NJ 08903

The Relationship of Piagetian and Piagetian-Like  
Tasks to Physics Achievement

Dale R. Baker and David VanHarlingen  
Rutgers University  
New Brunswick NJ 08903

Evaluator:

Thomas Teates  
College of Education  
Virginia Polytechnic Institute  
and State University  
Blacksburg VA 24061

# ANALOGY AND PHYSICS ACHIEVEMENT

Morris A. Enyeart  
Rutgers University  
New Brunswick NJ 08903

## Objectives and Rationale

Given the fact that the use of analogies is one of the most common forms of presenting new concepts in science texts, it is surprising to find that most of the research in analogical reasoning has been with formal analogies of the A:B::C:D type and not with the paragraph form used by science texts. Studies that have dealt with analogies of the latter type have generally arrived at the same conclusion; e.g., the use of analogies does not aid comprehension of the desired concept.

This study was designed to investigate the following:

1. Is interpretation of paragraph analogies a form of analogical reasoning?
2. When an S reads a paragraph, does he comprehend the analogy?
3. Is it necessary to be formal (Piagetian) in order to comprehend an analogy, regardless of its form?
4. Is analogical reasoning related to proportional reasoning?
5. Is physics achievement related to either form of analogical reasoning.

## Methodology and Design

The sample consisted of 37 students enrolled in an introductory physics course at a large eastern university. During a three-day period, Ss were given tasks designed to measure analogical reasoning ability and Piagetian Level. Tasks and Ss were each divided into three groups. By rotating the order in which tasks were given to each group, the researcher was able to control for possible learning effects. Course achievement was indicated by individual scores on the midterm exam, final exam and total course score.

## Instruments and Data

Both clinical and non-clinical tasks were administered to determine Piagetian Level with respect to proportions, combinations, permutations and probability. Analogical reasoning ability was measured using a test containing formal analogies of the type used in intelligence testing. A second test related to analogical reasoning required Ss

to read a paragraph containing an analogy that had been taken from their physics text, and then select the correct analogy presented in the paragraph from a list of four formal analogies which were similar in format to those in the first analogies test.

Data was analyzed using Pearson Correlations, t-tests and factor analysis.

### Results

1. Ss scores on the two analogical reasoning tests were significantly, positively correlated ( $p \leq .001$ ).
2. Proportional reasoning and formal analogy success was significantly, positively correlated ( $p \leq .001$ ) and loaded on the same factor.
3. Proportional reasoning and paragraph analogies were not significantly correlated and loaded on different factors.
4. Only analogies of the A:B::C:D type required the Ss to be formal in terms of Piagetian Level.
5. Both types of analogical tasks had significant, positive correlations with the physics achievement measures.
6. Ss were able to comprehend analogies when presented in paragraph form.

### Conclusions

When speaking of analogical reasoning, researchers in the past have assumed there was a single set of abilities used in solving problems of this type. That this is not true is indicated by the fact that a change to paragraph form no longer necessitates the use of proportional reasoning. Nor is the paragraph form related to Piagetian Level as is the A:B::C:D type of analogy. As indicated by previous research, paragraph analogies do not aid comprehension of a concept. It is not, however, due to the fact that Ss do not understand the analogy being presented.

SPATIAL REASONING AND FORMAL THOUGHT AS FACTORS IN  
SCIENCE ACHIEVEMENT FOR NEW ZEALAND STUDENTS

Michael D. Piburn  
Rutgers University  
New Brunswick NJ 08903

Research suggests that Piaget's Balance and Shadows tasks require an element of spatial reasoning for completion. It also seems reasonable to propose that formal thought and spatial reasoning may be factors in science achievement. One test case is gender-related differences in spatial and/or analytical tasks and success in science. This study was conducted to test the hypotheses that:

- a. Spatial reasoning and success on Piaget's Balance and Shadows tasks are related to one another and to science achievement; and that
- b. Sex-linked aspects of intellectual functioning are related to differences in success by males and females in achievement in science.

All 5th Form (year 10) New Zealand students take a national School Certificate examination which may include a General Science section. The sample for this study consists of 39 of 42 6th Form (year 11) students who were certified for University Entrance by a Christchurch High School, and had also taken the School Certificate (Science) Examination the previous year.

Measures were Piaget's Balance and Shadows, Card Rotations and Surface Development from an ETS factor-analyzed battery, and achievement on the School Certificate (Science) examination.

Success rates for this sample were high. Subjects were nearly evenly divided in number between those fully formal on either or both Piagetian measure (Formal) and those less successful (Pre-Formal). There were significant differences between scores on the Card Rotations, Surface Development, and School Certificate (Science) measures for these two groups. Significant correlations were obtained for the School Certificate (Science) Examination X Shadows, Balance and Surface Development, and for scores for Balance plus Shadows X Surface Development.

Males achieved significantly higher scores than females on the School Certificate (Science) examination and the Shadows task. A Chi-square test shows females less successful in achieving Late Formal on the Shadows task. Further analysis shows that the most favorable situation for male success on the School Certificate (Science) examination is to be Formal and above the median on the Surface Development test. In contrast, females are most seriously disadvantaged only by being Pre-Formal and below the median on the Surface Development test.

THE EFFECT OF A COMMUNITY COLLEGE EDUCATION ON THE COGNITIVE  
DEVELOPMENT OF STUDENTS IN LIBERAL ARTS AND LABORATORY  
TECHNOLOGY CURRICULA: AN INTERVENTION STUDY

Alan Sherman  
Rutgers University  
New Brunswick NJ 08903

Most students who enter a community college do so to learn a profession. It is also true that a community college education tends to focus on the achievement of specific skills. But does this type of education help the student to grow cognitively? It is the purpose of this study to answer that question.

In order to answer the above question, two areas of cognitive development were studied: combinatorial logic and proportional logic. Piaget's theory of cognitive development was used as the framework to measure cognitive growth. The sample consisted of male students between the ages of 17 and 19 years old who were entering freshmen when the study began. Forty subjects were enrolled in the laboratory technology curriculum—a career oriented program, and 40 subjects were enrolled in the liberal arts curriculum—a nonscience, general education curriculum, for students who wish to transfer to upper division colleges.

Each subject was pretested at the beginning of the semester to obtain a cognitive level in combinatorial and proportional logic. Each subject was posttested at the end of the academic year. Twenty-eight laboratory technology students and 29 liberal arts students completed the study. Various hypotheses were tested to determine if the students in these two curricula were at the same cognitive level at the beginning of the academic year and to see if cognitive growth occurred by the end of the academic year. In this way it could be inferred that college curricula act as interventions to increase cognitive development. Data analysis was performed using Chi-square and other non-parametric statistics.

An analysis of the data showed that for pretests, the cognitive levels of both groups of students were the same in both combinatorial and proportional tasks. An analysis of the data showed that for the posttests the cognitive levels of both groups of students were the same for the combinatorial tasks but not for the proportional tasks. The science group did much better on the postproportional tasks than did the liberal arts group. It is argued that this is evidence that cognitive development involving proportional reasoning did occur for those students enrolled in the laboratory technology curriculum.

# THE RELATIONSHIP OF PIAGETIAN AND PIAGETIAN-LIKE TASKS TO PHYSICS ACHIEVEMENT

Dale R. Baker  
David VanHarlingen  
Rutgers University  
New Brunswick NJ 08903

The purpose of this study was to identify those Piagetian and Piagetian-like tasks which are associated with success in physics so that the competencies these tasks represent can be incorporated into course work or a remediation program. It has been found that mathematical ability is a necessary but not sufficient condition for success in college physics (Hudson, 1977).

Thirty-eight students at a large eastern university enrolled in an introductory physics course participated in this study. The following tasks were given: separation of variables (Kuhn, 1977), shadows (Inhelder and Piaget, 1958), combinations and permutations after Piaget, Mr. Tall (Karplus, 1970), proportional word problems (Peterson, et al., 1978), a hypothesis testing task (Bady, 1978), and correlations (Lawson, 1978). All tasks were paper and pencil except the shadows which was administered clinically to each student.

A factor analysis was performed on the data and it was found that factor one accounted for 36.6 percent of the variance and was composed primarily of the proportional word tasks. Factor two was identified as hypothesis testing accounting for an additional 19 percent of the variance, for a total of 55.1 percent of the variance. It was not possible to identify any clear pattern on the other two factors.

Pearson correlations were also examined between the tasks, their component parts and student grades on the physics midterm and final exam. The shadow task, proportions, permutations and the hypothesis testing task all had significant correlations ranging from .62 ( $p \leq .001$ ) to .28 ( $p \leq .03$ ). Separation of variables and combinations did not correlate with the midterm or final exam. No sex differences were found.

From the factor analysis and the correlations it can be seen that the ability to do proportions is related to success in physics (Mr. Tall, word problems and shadows). However, it remains to be seen how much of the proportional ability is a reflection of a broader requirement of physics, namely mathematical ability. Formal operational thought is also related to success in physics (shadows and hypothesis testing task).



## References

- Bady, Richard. "Effects of Taking Science on Formal Logical Reasoning Ability." Annual Meeting NARST, Toronto, 1978.
- Hudson, H. T. and W. R. McIntire. "Correlation Between Mathematical Skills and Success in Physics." American Journal of Physics, 45(5):470-471, May 1977.
- Inhelder, Barbel and Jean Piaget. The Growth of Logical Thinking From Childhood to Adolescence. New York: Basic Books, Inc., 1958.
- Karplus, Robert and R. Peterson. "Intellectual Development Beyond Elementary School II: Ratio, A Survey." School Science and Mathematics, 70(9):813-820, December 1970.
- Kuhn, Deane and J. Brannock. "Development of the Isolation of Variables Scheme in Experimental and Natural Experiment Contexts." Developmental Psychology, 13:9-14, 1977.
- Lawson, A. and H. Adi. "The Acquisition of Propositional Logic and Advanced Cognitive Strategies in Grades Six through Fourteen." Annual Meeting NARST, Toronto, 1978.

CONCURRENT SESSION H

Session H-3

Learning

Presiding: Juanita Chitwood  
Newton County Board of Education  
Covington GA 30267

Sex Differences Among Early Adolescents in  
Learning a Spatial Visualization Skill

Walter S. Smith and Cynthia I. Litman  
University of Kansas  
205 Bailey Hall  
Lawrence KS 66045

The Effects of Setting Novelty and Number of  
Available Relevant Examples on Field Trip  
Behavior and Learning

John D. Balling and John H. Falk  
Smithsonian Institution  
Chesapeake Bay Center for Environmental Studies  
P.O. Box 28  
Edgewater MD 21037

Sex-Related Differences in Rate of Concept Attain-  
ment

Ann C. Howe  
Dept. of Science Teaching  
Syracuse University  
101 Heroy  
Syracuse NY 13210

Evaluator: A. W. Strickland  
Indiana University  
School of Education  
Bloomington IN 47401

SEX DIFFERENCES AMONG EARLY ADOLESCENTS IN LEARNING  
A SPATIAL VISUALIZATION SKILL

Walter S. Smith  
Cynthia I. Litman  
University of Kansas  
Lawrence, KS 66045

Objectives and Rationale

Adolescent and adult males have consistently outperformed females on tests of spatial ability; but a similar difference, if one exists, has not been so consistently found among children (Maccoby and Jacklin, 1974). Although a sex difference appears to be well substantiated for people at some, if not all, ages, the relationship of sex and instruction to spatial ability has been little understood (Eliot and Fralley, 1976). Smith and Schroeder (1978) found that fourth grade boys and girls did not differ in a two-dimensional spatial visualization task based on Elementary Science Study's Tangrams (1976); and both sexes improved significantly as the result of instruction.

Since sex differences in spatial ability had been found among adolescents but not among children (up through the fourth grade), and since instruction had been shown to have a positive effect among fourth grade girls and boys, the present authors asked (1) whether a sex difference in spatial ability existed among early adolescents (sixth and seventh graders) and (2) whether their spatial ability would be differentially affected by instruction.

Methodology, Design and Instrument

In order to answer these questions, a 2 x 2 factorial design with spatial ability as the criterion variable was used. Main effects were sex and instruction (i.e., whether or not instruction was received prior to the criterion test). Spatial ability was measured by the Spatial Visualization Abilities Test, SVAT (Smith and Schroeder, 1978). The SVAT presents the student with three progressively more difficult Tangram puzzles and measures the total time taken to complete the puzzles. Instruction in spatial visualization took place over four one-hour periods on succeeding days and followed the description of instruction by Smith and Schroeder (1978) which emphasized skills needed to solve Tangram puzzles. Boys (N = 32) and girls (N = 27) were randomly assigned to the instruction or noninstruction groups. The study was conducted in a parochial school primarily serving blue collar families in a medium-sized midwestern city.

## Results

An analysis of the SVAT data showed a significant interaction between sex and instruction ( $F = 4.89$ ,  $p \leq .05$ ). Post hoc analysis, using the Scheffe method, showed that noninstructed girls significantly outperformed noninstructed boys ( $F = 15.74$ ,  $p \leq .05$ ); and instructed boys significantly outperformed noninstructed boys ( $F = 12.14$ ,  $p \leq .05$ ). All other pairwise comparisons were not significant.

## Conclusions

Contrary to the findings of previous studies, early adolescent girls outperformed boys of the same age in a spatial abilities task prior to instruction. Whereas Smith and Schroeder (1978) had found that instruction significantly improved the spatial ability of both male and female fourth graders, the present study found that similar instruction of slightly older students (i.e., sixth and seventh graders) led to significant improvement only for the boys.

## Implications

The results of this study, when coupled with the findings of Smith and Schroeder (1978), indicate that instruction in spatial visualization ought to be provided in the fourth grade (prior to adolescence), if both girls and boys are to benefit significantly from the instruction.

## References

- Eliot, J. and J. S. Fralley. "Sex Differences in Spatial Abilities." Young Children, 31(6):487-498, 1976.
- Maccoby, E. E. and C. N. Jacklin. The Psychology of Sex Differences. Stanford, CA: Stanford University Press, 1974.
- Smith, W. S. and C. K. Schroeder. "Instruction of Fourth Grade Girls and Boys on Spatial Visualization." Science Education, 1978 (in press).
- Tangrams: Using A Puzzle to Investigate Problems in Area. New York: McGraw-Hill, 1976.

THE EFFECTS OF SETTING NOVELTY AND NUMBER OF AVAILABLE RELEVANT  
EXAMPLES ON FIELD TRIP BEHAVIOR AND LEARNING

John D. Balling  
John H. Falk  
Smithsonian Institution  
Edgewater MD 21037

The purpose of this study was to investigate the combined effects of two environmental variables—setting novelty and setting relevance—that are commonly assumed to be important to the educational process in general and that are often used to justify field trips. The relative novelty of the physical environment for a learning task has previously been shown to have significant effects on children's overt behavior and cognitive learning, both in the laboratory and in outdoor settings (Falk, Martin and Balling, 1978; Lubow, Rifkin and Alck, 1976). Although rarely investigated, the relevance of the setting for learning the material presented to the student is also an important variable to consider, especially since the reason most educators give for conducting outdoor based learning activities is that more concrete examples of natural phenomena can be discovered outside, rather than inside, the classroom. Based upon Berlyne's (1960) theorizing, it was hypothesized that students unfamiliar with complex natural settings, such as forests, should benefit most from outdoor field trips to relatively simplified biological environments with a small number of highly salient real-world examples relevant to the lesson being taught. On the other hand, students with more experience in natural environments should perform better in complex environments that can remain interesting with repeated exposure and where some of the subtleties of the natural world can begin to be appreciated.

The activity selected for this study was designed to help children understand the diversity, structure, and function of trees in an ecosystem. Children compared leaf shapes, trunk diameters, bark textures, and bark colors among many trees. In order to manipulate the number of relevant examples, three different settings, which varied greatly in the number of trees they contained, were used, namely a small urban park on a busy street corner, a quiet suburban park, and a mature forest area within a very large park. The relative novelty of the environment was varied by using subjects who, by virtue of their place of residence, were differentially familiar with the experimental settings. Samples were drawn from urban, suburban, and rural populations of children, roughly equivalent in socio-economic status. Thus, three levels of setting relevance, as defined by the number of examples (trees) available for study, and three levels of familiarity with the setting were manipulated in a factorial design. The students in a total of 15 fifth and sixth grade classrooms were used as subjects. Each class was divided into thirds, and the children in each group were assigned to do the field trip activity in one of the three experimental locations. For all subjects, the experimental task was done in the context of an all-day

field trip away from school. Pretests were given to the subjects several weeks in advance of the trip in order to determine their knowledge of the three settings and the material to be learned in the activity, as well as the extent of their outdoor experience. A posttest, which was designed to measure both cognitive learning and attitudes, was given to the subjects immediately following the activity. Observations of student behavior during the activity were also taken.

A discussion of results will be presented, including the analyses of the cognitive, affective, and psycho-motor behaviors of elementary school students on outdoor science field trips as a function of setting novelty and relevance. The nature of the interaction of these two environmental variables will also be discussed. A theoretical model that should provide pedagogical guidelines for field trip site selection will be presented.

#### References

- Berlyne, D. C. Conflict, Arousal, and Curiosity. New York: McGraw-Hill, 1960.
- Falk, J. H.; W. W. Martin; and J. D. Balling. "The Novel Field-Trip Phenomenon: Adjustment to Novel Settings Interferes with Task Learning." Journal of Research in Science Teaching, 15:127-134, 1978.
- Lubow, R. E.; B. Rifkin; and M. Alck. "The Context Effect: The Relationship Between Stimulus Pre-exposure and Environmental Pre-exposure Determines Subsequent Learning." Journal of Experimental Psychology: Animal Behavior Processes, 2:38-47, 1976.

# SEX-RELATED DIFFERENCES IN RATE OF CONCEPT ATTAINMENT

Ann C. Howe  
Syracuse University  
Syracuse NY 13210

## Rationale

Sex differences in performance, favoring boys, have been reported for several Piaget tasks which are closely related to concepts and topics in the science curriculum. The poorer performance of girls may be interpreted as reflecting an experiential deficit (an environmental factor) or a slower developing mental structure (a genetic factor). If the difference is due to a lack of necessary experience on the part of girls, then they should perform as well as boys on the tasks if they are given the prerequisite experiences. If, on the other hand, they lack the requisite mental structure, then the provision of experiences should not make a significant difference in their performance on the tasks.

## Objectives

The purpose of the present study was to find some evidence which might be brought to bear on the issue raised above. Answers were sought to the following questions: (a) Is there a sex-related difference at ages 9-11 on response to a volume-density task? (b) Will performance on the task be affected by classroom instruction? (c) Will performance of boys and girls be affected similarly?

## Method

Data collected from two groups of children were used. The 64 children in Group I were pretested, taught a series of lessons which provided what was thought to be relevant experience, and posttested. The time which elapsed from pretest to posttest was seven months. Their posttest scores were compared to scores of children of similar age who had not received the specified instruction. The 96 children in Group II were divided into experimental and control groups, pretested, taught a series of lessons similar to those taught to the children of Group I, and posttested. The elapsed time from pretest to posttest was one month.

## Instruments

Similar tests of conservation of volume and density, composed of items derived from Piagetian literature, were administered to the two groups. The experimenter demonstrated the tasks to one class at a time; children marked answers on response sheets. Test-retest reliability and item analysis data are available for both tests. The data were analyzed by means of analysis of variance and correlational techniques.



## Results and Conclusions

The previous findings of significant sex differences were confirmed. A significant training effect, as shown by improved performance of those who had received instruction, was also found. The scores of both boys and girls improved after instruction but, although the girls' scores improved more than the boys', the difference was not statistically significant. The girls were at approximately the same level after instruction as the boys had attained before instruction.

Results are interpreted as favoring an interactive model of development in which experience and structure cannot be separated since structure is built as a result of experience and the manner and degree to which experience is assimilated is determined by the structure already present. Implications for curriculum development will be discussed.

CONCURRENT SESSION H

Session H-4

Instruction

Presiding:

William C. Ritz  
School of Natural Sciences  
California State University  
Long Beach CA 90840

The Effects of Diagnosis, Remediation and Locus  
of Control on Achievement, Retention, and Atti-  
tudes of Middle School Science Students

Ramona L. Saunders and Russell H. Yeany  
Dept. of Science Education  
University of Georgia  
Athens GA 30602

The Effects of a Diagnostic-Prescriptive Teaching  
Strategy on the Achievement and Attitudes of High  
School Biology Students

Joe C. Long  
Northeast Georgia Cooperative  
Educational Service Agency  
375 Winter Street  
Winterville GA 30683

and

James R. Okey and Russell H. Yeany  
Dept. of Science Education  
University of Georgia  
Athens GA 30602

The Effects of Diagnostic Prescriptive Instruction  
and Locus of Control on Different Cognitive Levels  
of Science Achievement in University Students

Russell H. Yeany, Richard J.  
Dost and Robert W. Matthews  
Dept. of Science Education  
University of Georgia  
Athens GA 30602

Evaluator:

David R. Stronck  
Faculty of Education  
University of Victoria  
P.O. Box 1700  
Victoria, British Columbia  
Canada V8W 2Y2

THE EFFECTS OF DIAGNOSIS, REMEDIATION, AND LOCUS OF CONTROL  
ON ACHIEVEMENT, RETENTION, AND ATTITUDES OF MIDDLE  
SCHOOL SCIENCE STUDENTS

Ramona L. Saunders  
Russell H. Yeany  
University of Georgia  
Athens GA 30602

Objectives and Rationale

The objectives of this study were to determine the effects of diagnostic testing followed by prescribed remediation on the immediate and retained science achievement of middle school students, and to determine if effects of treatment were consistent across student's race and locus of control (LOC) levels.

In the main, achievement tests are used as summative measures for the purpose of determining what students know and for assigning grades. An equally viable purpose of testing is to provide diagnostic information to guide remediation activities. Formal diagnosis can pinpoint misconceptions and learning difficulties and allow for prescribed remediation prior to summative evaluation.

The degree to which a student acts on the feedback from diagnostic testing and attends to the remediation may depend on special characteristics of the learner. One of these is locus of control. It is possible that "internal" individuals will act more readily upon the feedback and opportunity for remediation, while "external" persons might view their learning success as being more controlled by others and not attend to the feedback.

Methodology and Design

The three independent variables in this study were: type of diagnostic-remediation treatment, level of locus of control, and race of student. Three intact classes (N = 76) were randomly assigned to the following treatment levels:

**COMPARISON LEVEL: OBJECTIVES ONLY.** Subjects in this group received a set of 27-objectives followed by three weeks of instruction (on the first 15 objectives), the first summative test, two more weeks of instruction, then the second summative test. Instruction included lecture, reading, and viewing filmstrips and slides, and observing laboratory demonstrations.

**EXPERIMENTAL LEVEL I: DIAGNOSTIC LEVEL.** These subjects received the same objectives and instruction as the "objectives only" group. In addition, this group received a diagnostic measure after each set of five objectives.

Students who failed to master an objective were so informed and required to take a second parallel diagnostic measure two days later. No suggestions for remediation were given.

EXPERIMENTAL LEVEL II: DIAGNOSTIC/REMEDIATION LEVEL. Subjects in this group received the same treatments as the first two levels with the exception that students who failed to master an objective on the first diagnostic measure were given remedial assignments to complete before taking the second diagnostic measure.

Data were analyzed using ANCOVA procedures in a  $3 \times 2 \times 2$  (treatment  $\times$  LOC  $\times$  race) factorial design. As mentioned above, there were two experimental groups and one comparison group. In addition, each group was stratified on two levels of locus of control (internals and externals) and two levels of race (black and white). Pre-treatment achievement data were used as the covariates.

### Instruments and Data

A series of parallel items was developed for use as diagnostic, achievement and retention test items. No item was used twice. The content validity of the items was insured by comparing them to the specific objectives. The KR21 reliabilities of the three achievement tests were .94, .74 and .94. The first summative test was administered after three weeks of instruction and the second at the end of five weeks. The retention measure was administered to all three groups one month after the end of treatment.

Prior to treatment, data on the locus of control variable were collected with a modified, Rotter LOC measure. Student's attitude toward the use of objectives, diagnosis and remediation was measured using Likert scale items.

### Results

Although immediate achievement was not significantly increased by diagnostic remedial treatments ( $p \leq .05$ ), the students who experienced diagnostic/remedial instruction showed a 10-12 percent greater retention of science concepts ( $p \leq .05$ ).

Also, on the second summative measure and on the retention measure, internal LOC students scored significantly higher than external students ( $p \leq .05$ ). On the second summative measure, the diagnostic treatment favored internal subjects slightly more than external subjects ( $p \leq .05$ ).

White students showed greater retention than blacks but a significant treatment by race interaction indicated that these differences were reduced through the use of diagnostic remedial instruction ( $p \leq .05$ ).

Although there was no affective impact of treatment, race, or LOC, the attitudes of the students were positive.

### Conclusions

Both internals and externals, and blacks and whites, benefitted from diagnosis, and diagnosis and remediation. It should also be noted that retention differences between blacks and whites were reduced by the use of remediation. The use of diagnostic remedial strategies proved to be more effective than not using them; therefore, these methods should be considered as a means of improving retained achievement in middle school science classes.

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THE EFFECTS OF A DIAGNOSTIC-PRESCRIPTIVE TEACHING STRATEGY  
ON THE ACHIEVEMENT AND ATTITUDES OF HIGH SCHOOL  
BIOLOGY STUDENTS

Joe C. Long  
Northeast Georgia Cooperative  
Educational Service Agency  
Winterville GA 30683

and

James R. Okey  
Russell H. Yeany  
University of Georgia  
Athens GA 30602

Objectives and Rationale

In order to provide instruction based on individual need, teachers can employ methods to determine the entry level capabilities of pupils before instruction begins and to monitor pupil progress as instruction proceeds. It is further suggested that teachers then prescribe instruction based on the needs identified from diagnosis of the individual learner. This strategy is defined as diagnostic-prescriptive (d-p) teaching.

Variations in types of d-p assistance give rise to a variety of questions or concerns. Can the task of d-p management be delegated to students with effectiveness, comparable to a teacher-managed strategy? Although diagnostic-prescriptive learning assistance may be shown to effect significant increases in achievement, is administration and management of the task an obstacle to large-scale implementation?

The degree to which a student is a successful participant in a diagnostic-prescriptive environment may depend in part on special characteristics of the learner. The personal variables examined as main effects in this study are aptitude and locus of control (LOC). It is possible that those individuals classified as internal with regard to LOC or high academic aptitude may exhibit a greater willingness toward participation in the d-p classroom.

The objectives of this study were:

1. To measure the effects of three variations in the use of diagnostic-prescriptive teaching, locus of control, and aptitude on the cognitive and affective biology achievement of high school students.
2. To determine if the effects of treatment (diagnostic-prescriptive teaching) were consistent across levels of student aptitude and locus of control.

## Methodology and Design

The experimental sample consisted of all students (N = 93) enrolled in three Biological Sciences Curriculum Study (BSCS) biology classes. Intact classes were randomly assigned to the following treatment levels for the six weeks of this study:

**CONTROL LEVEL:** No Diagnostic-Prescriptive Assistance. This level included subjects who received instruction, but did not receive diagnostic tests or any remediation prescribed by the instructor or required by virtue of objectives of the course.

**EXPERIMENTAL LEVEL I:** Teacher Managed Diagnosis and Prescription. This level included subjects who received diagnostic tests, feedback on performance, and prescriptive remediation from the teacher.

**EXPERIMENTAL LEVEL II:** Student Managed Diagnosis and Prescription. This level included subjects who received diagnostic tests from the teacher. Scoring the diagnostic test, assessing progress on current objectives (i.e., feedback on performance), and undertaking remediation was a responsibility delegated to the student.

Diagnosis was conducted through the use of objective-referenced, brief, pencil and paper instruments named progress checks to convey the notion to students that there was no penalty for the identification of their learning problems.

All subjects were stratified on measures of aptitude (high, middle, and low) and locus of control (internal and external). This permitted measures of the dependent variables to be analyzed within a 3 x 3 x 2 factorial design which consisted of three levels of treatment, three levels of aptitude, and two levels of locus of control.

Data were analyzed through analysis of variance, analysis of covariance, and selected multiple comparison procedures. Pre-treatment achievement data were used as the covariates.

## Instruments and Data

Three measures pertaining to biology achievement were used in the study: (a) pre-treatment biology achievement scores to be used as covariates, (b) treatment-period biology achievement scores to be used as criterion variables, and (c) a measure of attitudes toward biology content and instruction. Content validity of the cognitive tests was established by comparing items to the specific objectives. KR20 and KR21 reliability estimates of the various measures ranged from .71 to .91.

Prior to treatment, aptitude data was collected by use of the School and College Ability Test (SCAT). Locus of Control orientation was assessed by administering the Rotter I-E Scale.



### Results and Conclusions

Significant treatment effects were detected on all four measures. The effects of aptitude and locus of control, when adjusted for pre-treatment differences, proved to be non-significant. A significant treatment by locus of control interaction was detected on the first cognitive measure. The group receiving teacher-managed learning assistance scored higher on all cognitive measures. On the other hand, those students managing their own learning-assistance system held a more positive viewpoint in attitudes toward biology content and instruction.

THE EFFECT OF DIAGNOSTIC PRESCRIPTIVE INSTRUCTION AND LOCUS  
OF CONTROL ON DIFFERENT COGNITIVE LEVELS OF SCIENCE  
ACHIEVEMENT IN UNIVERSITY STUDENTS

Russell H. Yeany  
Richard J. Dost  
Robert W. Matthews  
University of Georgia  
Athens GA 30602

Objectives and Rationale

In the main, achievement tests are used as summative measures for the purpose of determining what students know and assigning grades. An equally viable purpose of testing is to provide diagnostic information to guide remediation activities. Formal diagnosis can pinpoint misconceptions and learning difficulties and allow for prescribed remediation prior to summative evaluation.

The degree to which a student acts on the feedback from diagnostic testing and attends to the remedial assignment may depend on special characteristics of the learner. One of these is Locus of Control. It is possible that the "internal" individual will act more readily upon the feedback and opportunity for remediation, while an "external" person might view their learning success as being more controlled by others and not attend to the feedback.

The objectives of this experimental study were to determine the effects of objective referenced formative diagnostic testing followed with remediation assignments on three cognitive levels of science achievement and the attitudes of university students, and to determine if the effects of treatment were consistent across student locus of control levels.

Methodology and Design

The independent variables in this study were type of instructional treatment and level of locus of control. The treatment levels are defined as follows:

COMPARISON LEVEL: OBJECTIVES ONLY (0). The usual procedure in the course was to provide each student with performance objectives which guided instruction and student evaluation. The instructional unit used in the study consisted of 16 objectives. The subjects in this treatment level received the usual unit objectives and experienced instruction which included lecture-discussions, a slide tape presentation, two laboratory sessions and one homework assignment. The instructional procedures were not unique to the unit; the sessions were considered normal for the course.

**EXPERIMENTAL LEVEL: DIAGNOSIS AND PRESCRIPTION (DP).** Subjects in this treatment level received the same objectives and instruction as the above group and followed an identical time schedule. In addition, they completed regular diagnostic measures which were keyed to the objectives and received remedial assignments when necessary.

The diagnostic activities occurred during the first five minutes of each session. Each student completed a short quiz on the objectives covered during the prior session. The quizzes were then marked by an assistant while the students were engaged in instruction toward the next subset of objectives.

For each of the objectives, two remedial assignments had been selected. Each subject had a file folder from which he obtained the diagnostic measure at the beginning of the session and the necessary remedial assignments at the end of the session. If a student received a remedial assignment, he was rediagnosed on those objectives the next session along with the diagnosis for the subset of objectives. Students were not required to master the objectives before the class proceeded. Also, no time was taken to reteach an objective. Remediation was prescribed by the instructor but was the responsibility of the student.

#### Data Sources

The subjects in the study were 60 university students enrolled in an introductory biology course at the University of Georgia. Pre-treatment data were collected on the average achievement level of each student on the units of study covered prior to experiment conditions. These data were used as covariates to adjust for selection bias and increase statistical power of the analysis. Pre-treatment data were also collected on student Locus of Control as assessed by the Rotter LOC Measure. Subjects were then stratified as internal or external. Post treatment achievement data at three cognitive levels (i.e., knowledge comprehension, and higher) were collected at the end of the unit along with affective data to measure the subjects' attitudes toward the nature of the instruction.

All measures were item analyzed to insure adequate reliability and validity.

#### Results

ANCOVA procedures indicated that, on the total achievement measure, the DP group achieved significantly higher than the Objectives Only group ( $p \leq .04$ ). This difference represented a 10 percent increase in achievement. When the cognitive level subtest data were analyzed, the differences in achievement existed in the recall level items ( $p \leq .05$ ). No other influences of treatment on achievement existed.

And, no effects on locus of control on achievement or LOC by treatment interactions were found. Although the mean attitude scores were positive, there were no significant differences in attitude which could be attributed to treatment.

### Importance

The results of this study indicate that science achievement can be increased with the use of diagnostic prescriptive instruction; although, the greatest impact appears to be on low level learning. Also, the effects of treatment are consistent across internal and external students and bring about achievement gains with no decline in the affective dimension. With the present concern over declining achievement in the sciences, the treatment investigated in this study deserves serious consideration as a means of improving achievement.

CONCURRENT SESSION H

Session H-5

Round Table: Annual Review of Science Education Research

Presiding:

Glen Aikenhead  
College of Education  
University of Saskatchewan  
Saskatoon, SASK  
Canada S7N DWO

Reflections on Writing an Annual Review and  
Summary of Research in Science Education

Rita W. Peterson  
California State University  
Hayward CA 94542

Evaluator:

William Brown  
Science Education  
Old Dominion University  
Norfolk VA 23508

REFLECTIONS ON WRITING AN ANNUAL REVIEW AND SUMMARY  
OF RESEARCH IN SCIENCE EDUCATION

Rita W. Peterson  
California State University  
Hayward CA 94542

As competing demands for our time increase, so does our reliance on reviews of research for keeping abreast of the important trends and issues in areas of our professional interest. Yet, authors and readers of annual reviews or periodic summaries of research presently face some serious problems which require discussion.

The purpose of this round table discussion is to promote the exchange of information. First, one author of a recent annual ERIC review will provide an inside view of the task of reading, summarizing and synthesizing the research in science education for one year, and will share some concerns about problems that may increasingly confront those who rely on research reviews in their work. Second, those who are familiar with annual or periodic reviews of research will be encouraged to discuss these problems and share their views on how such publications might become more useful.

The initial thrust of the round table discussion will be directed toward two concerns that grew out of writing the most recent annual review of research for ERIC. The major problem facing the research community in this last quarter of the twentieth century, in the author's view, is how to deal with the knowledge explosion that has resulted from multivariate analysis research. We are faced with the fact that we are living in a multivariate research age and still trying to communicate in a univariate language. To illustrate, readers expect to read reviews that synthesize research in traditional categories like achievement or attitudes. Yet reviewers are increasingly met with studies which report multiple outcomes in achievement, attitudes, self-concept, and locus of control, in a single study which may involve a highly diverse population (e.g., varied in age, gender, ethnicity, affluence, reading level, etc.), with numerous interactions among dependent and independent variables. The problems associated with synthesizing multivariate studies or failing to account for their results in this knowledge explosion will be discussed in relation to improving communication in our research reviews.

A second problem which has concerned reviewers of research for much longer is the weakness or absence of theory among studies. More recently, a related concern is the alleged decline in basic or "pure" research itself. Kerlinger's paradox will be discussed: that if one wishes to increase the long-term impact of research in schools, one should invest in basic research, not applied research. The short-term "pay-off" and "relevance" of applied research versus the long-term value of basic research will be discussed in relation to standards for reporting or reviewing research in journals.

GENERAL SESSION III

**Presiding:** John W. Renner, President  
University of Oklahoma  
Norman OK 73019

**Topic:** The Impact of Paradigm-Based Research  
Upon Classroom Practice

**Speaker:** Rita W. Peterson  
Associate Professor of Science Education  
California State University  
Hayward CA 94542